

# **Assessing the Impact of Regulatory and Legislative Changes to the Independent Research and Development Program**

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## EXECUTIVE SUMMARY

Independent Research and Development (IR&D) is research and development initiated and conducted by industry. IR&D is viewed by industry as essential to advance technology, develop new and improved products, and develop new business. Since the late 1930s, IR&D carried out by firms developing and producing defense systems has been recognized by the U.S. government as a necessary cost of defense business and at least some percentage of this cost has been reimbursed by the government. What percentage is to be reimbursed, how that percentage is determined, and what type work is to be reimbursed have all been matters of debate.

The Department of Defense (DoD) IR&D Program is a vital element in the DoD's overall research and development effort aimed at ensuring U.S. forces continue to have a technological edge over any future foe. In FY 1995, reported reimbursable IR&D and Bid and Proposal (B&P) was about 12 percent of the overall DoD research and development budget. These funds enable industry to explore new technologies and next generation products.

Over the period of the Cold War, elaborate processes were developed to evaluate the value of the reimbursed technology to the Department of Defense (DoD) and to determine the level of reimbursement to the firm by the government. The DoD exercised considerable control over contractor IR&D activities that were allowable reimbursements. The technical quality of IR&D projects was scored by the government in a formal evaluation process which included an annual evaluation of contractor technical plans and bi-annual on-site reviews. The Department conducted annual ceiling negotiations of allowable costs of major contractors which considered technical scores and the military relevance of projects. These processes, while useful as management and communications tools, were costly and, by the late 1980s, both industry and the government were looking for ways to improve efficiencies. At the same time, important external events were occurring the Cold War was ending, defense budgets (particularly the procurement accounts) were dropping, and there was concern over the future viability of the U.S. defense industry.

In FY 1991, the DoD streamlined the IR&D reporting process, greatly reducing the size of the technical reports and the corresponding administrative burden on industry and the Services. In the FY 1991 Defense Authorization Bill, Congress broadened the criteria for allowable IR&D efforts to include work of "potential interest" rather than the previous more restrictive "potential military relevance."

In the FY 1992 and FY 1993 Defense Authorization Act, Congress made additional substantial changes to the DoD IR&D program. The new law eliminated both advanced negotiated agreements on IR&D and the formal technical review process. But, it allowed the DoD to develop regulations that provided for exchanges of information conducted "in a reasonable manner," between the DoD and contractors. There was a three year transition period (1992-1995), during which existing IR&D ceilings were increased by 5 percent per year. After that, firms were limited only by what they deemed prudent to spend while still remaining competitive. These changes essentially eliminated direct government control. Now, almost five years after these changes were made, and in the wake of significant and continuing restructuring within the defense industry, it appears prudent to examine the effects of these changes on the IR&D Program.

## STUDY OBJECTIVES AND APPROACH

The objectives of this study are to: (1) **describe industry IR&D before and after the administrative and legislative changes;** (2) **describe industry/DoD communication before and after the changes;** and (3) **evaluate selected DoD, IR&D activities.**

To achieve these objectives the study team developed a questionnaire (Appendix A), identified thirty firms from a representative cross-section of industry, and then used the questionnaire and interviews to gain insight on the study objectives.

The Study's principal findings and recommendations are summarized below. Findings are grouped into four categories: General, Investment, Communications, and Environment.

Some of the findings represent statements of fact that prompt no need for action. Other findings relate to problems or concerns that were identified by industry or the study team. In those cases, the study team has included a recommendation for action.

## FINDINGS AND RECOMMENDATIONS

### GENERAL

- **Finding:** The legislative and regulatory changes resulted in a fundamental change in the level of direct DoD control over IR&D.
- **Finding:** The legislative and regulatory changes have reduced perceived costs and administrative burden. Industry likes the changes.
- **Finding:** There has been a fundamental change in the character of government/industry communications.
- **Finding:** Companies are either increasing their involvement in defense or selling their defense interests and concentrating on commercial markets.  
**Recommendation:** DoD should analyze the potential impact of this trend in concentration on the transfer of commercial technology.

### INVESTMENT

- **Finding:** IR&D has fallen in absolute terms.
- **Finding:** The IR&D/B&P ratio has fallen slightly, but the trend remains unclear.
- **Finding:** There is an excessive near-term focus in IR&D projects. It poses a threat to continued defense technological dominance.  
**Recommendation:** The DoD should take immediate steps to identify and promote more long-term IR&D investments. Possibilities include:
  - (1) Improve the communication of future defense needs;
  - (2) Make greater use of mechanisms such as technology steering committees, technology centers and Integrated Product Teams; and
  - (3) Develop funded cooperative projects in selected technology areas.

- **Finding:** There is confusion over the appropriateness of process development IR&D investments.  
**Recommendation:** DoD should examine the current regulations dealing with process technology investments and the problems associated with such investments in the IR&D program.

### COMMUNICATIONS

- **Finding:** The feedback and utility of interaction based on technical data submissions is very low and marginally useful.  
**Recommendation:** The DoD should expand on current efforts to improve this interaction. It might, for example, also examine the use of Centers of Excellence, or other mechanisms to evaluate and report on submissions.
- **Finding:** Technical data interchange meetings have fundamentally changed.  
**Recommendation:** DoD should study the use and effectiveness of technology steering committees and their potential broader application.
- **Finding:** DoD planning documents and information are reportedly helpful to the large firms (less so for small firms), but confusing.  
**Recommendation:** DoD needs to take steps to improve the level of information and credibility of future technology needs and priorities. Again, the use of technology steering committees, or research centers may be helpful for specific technology areas.
- **Finding:** The formal technical interchange meetings are down, but the overall communication may be about the same.  
**Recommendation:** DoD might increase the level of travel funds so that relevant DoD personnel could attend on-site briefings.

### ENVIRONMENT

- **Finding:** Small companies are concerned that the large, vertically integrated companies can overwhelm the business and foreclose funded R&D projects, therefore ultimately creating a monopoly situation in key areas.  
**Recommendation:** DoD should study the impact of the vertical integration and evaluate the checks and balances which inhibit a large company from dominating a market.

- **Finding:** There is a trend toward decentralization of IR&D decision-making.  
**Recommendation:** DoD should study the degree of decentralization of IR&D decision-making and evaluate the implications of any identified trend for IR&D policy.
- **Finding:** Industry consolidations and the trend to decentralization has apparently reduced or eliminated many corporate research organizations.  
**Recommendation:** DoD should study this trend and evaluate its potential long-term implications.
- **Finding:** IR&D in explosives and propellants material may be consumed by the need to respond to changes in environmental laws that drive suppliers out of business and component products off the market.  
**Recommendation:** DoD should study this situation to determine if additional special funding is necessary.

## SUMMARY

**The fundamental IR&D policy question facing DoD is whether the Nation is receiving defense products commensurate with the level of program funding.** Answering this policy question demands an understanding of a number of factors including: research areas being addressed and how those areas match with identified defense needs; funds being spent; the changing structure of the defense industry; and the changing national security environment. It requires decisions on the yardsticks to be used to measure the efficiency of investments, and ways to compare these investments with alternatives.

While this study was not intended to answer this fundamental policy question, it does, however, provide valuable information for addressing that question.



## ASSESSING THE IMPACT OF REGULATORY AND LEGISLATIVE CHANGES TO THE INDEPENDENT RESEARCH AND DEVELOPMENT PROGRAM

### INTRODUCTION

The Department of Defense's reimbursable Independent Research and Development (including both IR&D and Bid and Proposal: B&P), in FY 1995, constituted about 12 percent of the Department's overall R&D budget. This is a very important element of the overall DoD R&D effort. It is important to industry too. Firms describe the IR&D effort as their "life-blood." The effort is the firm's investment in developing new business or widening its lead in current business areas.

Average spending on IR&D and B&P among defense firms was about 3.0 percent of total sales. (See Figure 1.) In comparison, according to some studies, U.S. commercial firms in 1995, spent on average, about 4.5 percent of sales on R&D. Roughly eighty percent of the money in the commercial sector was provided by industry itself, making the industry average IR&D investment in the future somewhat higher (about 3.6%) than that in the defense sector alone. These commercial sector IR&D funds generally came from profits on sales in established firms, or from the venture capital market for start-up firms.<sup>1</sup>

The level of IR&D spending varied by industrial sector for both the general industrial base and for defense firms. But regardless of the sector, IR&D and reimbursement for preparing bids and proposals, are considered critical elements of successfully doing business with the government.

For the government, such investments are important for enhancing American's national security. The government depends on new technological developments to ensure that its forces retain the technological edge that has distinguished them since the end of World War II.

In a purely commercial transaction, such R&D investments are included in the overall price of the good or service purchased and the customer either pays the stated price, or does not buy the product. In the case of government contracts, however, cost is usually the basis for the contract (e.g., cost-plus fixed fee, fixed cost). The government audits defense contracts with an

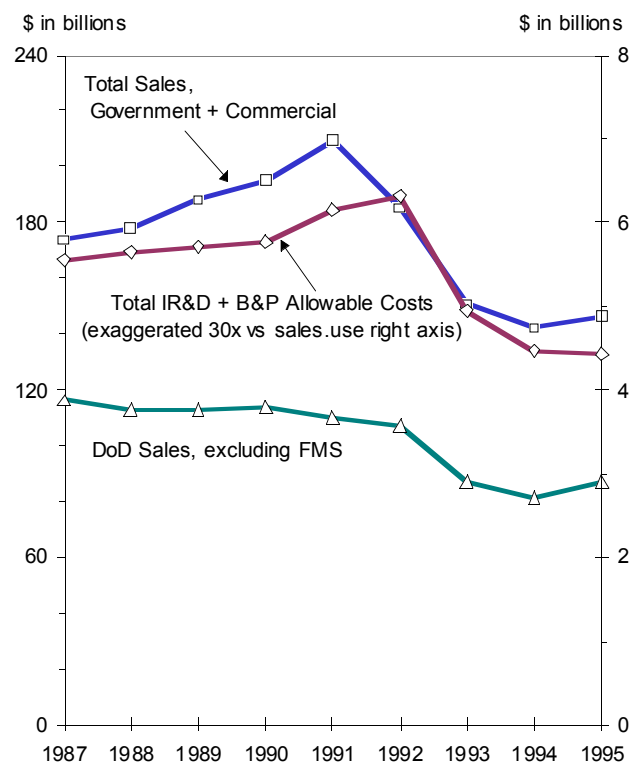


Figure 1: Combined IR&D and B&P vs. Sales

SOURCE: DCAA

eye to ensuring that all included costs are valid. Under these circumstances, the nature of the DoD IR&D program, the degree of reimbursement, and the degree of interaction with the government become very important to doing business with the government in any other mode than one of a strictly commercial transaction.

<sup>1</sup> Industrial Research Institute, *Industrial Research and Development Facts*, Washington, DC, July 1996, pp. 2-3.



In FY 1991 and FY 1992, the government made significant changes in the operating rules that governed the DoD IR&D program. In FY 1991, the DoD made administrative changes implementing a streamlined reporting process. Also in FY91, Congress broadened the IR&D allowability criteria by expanding the definition of R&D efforts that would be eligible for reimbursement by eliminating the requirement that such R&D have "potential military relevance" and replacing that phrase with one stating "potential interest"—a term that was broadly defined to include many activities that were not directly linked to defense systems.

Subsequent legislation (P.L. 102-190, National Defense Authorization Act for Fiscal Years 1992 and 1993) eliminated the requirement for negotiating advance agreement ceilings with large contractors and abolished the requirement for any formal IR&D technical review and evaluation of a contractor's IR&D efforts by the Services. The 1992 changes essentially eliminated direct government control of the IR&D process. During a three year transition period (1993-1995), the IR&D ceilings were increased by 5 percent/year, but after that, firms were limited only by what they deemed prudent to spend while still remaining competitive. Firms still, however, had to convince government auditors to accept the allowability of costs, but in theory this was not a problem given the "potential interest," rule. The changes also resulted in a much reduced requirement for formal communication of IR&D results, and much reduced formal interface with potential DoD customers.

There were a number of concerns expressed about the implications of these changes. One major concern was whether DoD would get an acceptable return on its reimbursed element of the IR&D. This was (is) not only a major concern, but it was (is) difficult to evaluate. This was true even when the IR&D investments were required to show direct military relevance. If work is focused on long-term investments it is often difficult to trace the ultimate product outcome. The result of short-term investments are easier to track. One way of evaluating is to consider the worth of the products developed. Some products reportedly developed from IR&D efforts are shown later in Box G.

The changes in the law directing that IR&D efforts no longer have to show military relevance made it possible for firms to work on technologies that were potentially of no interest to the Department of Defense. While the likelihood that a firm would put most of its IR&D effort into work that is of no value to the DoD is probably small, the bias in research toward non-defense might, overtime, have a negative effect on defense R&D efforts.

There were other important concerns. For example, while the costs of administering the IR&D program were expected to go down, the direct dialogue between industry and government would also probably be reduced. Certainly the formal exchanges would be reduced. It was not clear what the impact of reductions in this type of communication would be. In fact, a recent survey of several large firms appears to confirm some of the communications concerns. The firms expressed common complaints that they now have less understanding of DoD needs and desires, and there is now less feedback on their IR&D effort. However, here it is difficult to say for sure what portion of the increased problem in communications is a result of the mandated changes in procedures and what part is a result of changes in the national security environment.

The possibility of negative consequences of the changes resulting from reduced communications were increased by several trends in the national security environment. The first was the end of the Cold War. While this was a welcome change, it meant that any difficulties that might arise as a result of lack of communications of the DoD needs and desires were multiplied by the national security uncertainties associated with the end of the Cold War. For example, instead of the dominating threat from the Soviet Union and Warsaw Pact, the country now faces a variety of regional threats to its interests as well as to allies, and a growing threat of terrorism (foreign and domestic) at home.

This changing national security environment, and a falling defense budget, have driven another important trend: profound changes in the defense industry. Many firms have moved out of the defense business or gone out of business entirely. Within the defense sector, numerous consolidations have occurred. Within firms, the consolidations have greatly affected the

corporate structure, often with larger, more vertically integrated defense firms growing to encompass a wide array of products. The industry consolidation is not yet complete.

Now almost five years after the regulatory and legislative changes, it is appropriate to evaluate the impact of the changes, to consider the current effectiveness of DoD's IR&D program, and to identify actions that might improve the program.

## STUDY OBJECTIVES

The study directive from the DoD contained three principal objectives. The first is to: **describe the industry IR&D activity before and after the regulatory and legislative changes.** This objective specifically charged the study team to examine changes in:

- the character of the research (amount of defense v. non-defense work);
- the amount and ratio of IR&D to B&P; and
- the reporting of IR&D technical information to the DoD.

The second principal objective is to: **describe industry/DoD communications before and after the regulatory and legislative changes.** This objective included specific instructions to examine:

- the quality and quantity of technology planning and requirements information available to contractors;
- the DoD's review of contractors' plans and projects; and
- the feedback and utility of interactions based on the technical data submissions from contractors

The final objective is to **evaluate the adequacy of selected DoD, IR&D activities.** This task calls specifically for consideration of:

- technical interchange meetings;
- methods of matching defense requirements to IR&D projects; and
- oversight of the IR&D Program.

## APPROACH

The study team developed a questionnaire that addressed the three principal objectives.(see Appendix A). The questionnaire was reviewed by both DoD and industry personnel, and their comments and suggestions were incorporated.

The team identified a cross-section of potential study participants. Candidates were selected on the basis of size (small, as well as large), and industrial sector (aerospace, electronics, shipbuilding, combat systems, and munitions). An effort was made to include the major defense contractors and therefore the principal reimbursed IR&D providers. Some of the firms were contacted at the corporate level. Others were contacted at the operating division level. Some firms were contacted at both levels. Possible participants were contacted directly by the study team and thirty were identified as willing to participate. An effort was made to contact individuals who were responsible for the effectiveness of the IR&D investments. Ultimately twenty-one responses (verbal or written) were received based on the survey. Not all firms, however, answered all questions. In addition, interviews were conducted with other industry personnel and with current and former DoD personnel. Previous IR&D studies were also reviewed and DCAA data were examined.

### *Characteristics of the Industry Sample*

Many of the firms in the study are either large defense firms, or are subsidiaries of large firms. Indeed, the final study firms include the corporate data, or that of the major defense operating divisions, of 12 of the top 15 defense contractors in FY95. Together, the firms (or the operating divisions for which data were received) represent over 36% of total DoD purchases of goods and services for that year. They have a broad range of DoD customers, and provide a wide range of products\_ aircraft, ships, tanks, armored personnel carriers, ammunition, and a host of electronics components and subcomponents. (See Figure 2.) The firms vary in their degree of work for DoD, from less than 10% to 100%. Most, however, are heavily involved in defense work, with almost half of the firms having more than 80% of their sales with the DoD. (See Figure 3.)

The data indicate that the firms have moved to either increase their defense work through acquisitions, or have sought to decrease it through divestiture of major defense elements. (See Figure 5.) As a group, they appear to do more IR&D than the DoD reported 3% average. (See Figure 4.)

## REPORT ORGANIZATION

Two previous interim reports have been submitted. Both were organized around answers to the questionnaire. This final report is organized around the three principal study objectives. Findings and recommendations are summarized at the end of the report.

## BACKGROUND

The present DoD IR&D program had its beginnings in the 1934 Vinson-Trammell Act which limited profits on naval vessels and aircraft to 10 percent of the total contract price. In an earlier study of the IR&D Program, the RAND Corporation noted that: "This restriction on profits, defined as a percentage of contract price, demanded a definition of acceptable costs." A Treasury Department Decision (T.D. 5000) supplied that definition. It identified certain indirect R&D cost items that would be recognized by the government, including a reasonable portion of "general experimental and development expenses which may be charged off currently," indirect engineering expenses; and "bidding and general selling expenses."<sup>2</sup>

The requirement to define acceptable costs that flowed from the profit restrictions of the Vinson-Trammell Act was continued by the subsequent "excess-profits" tax and the pricing of contracts during World War II. However,

<sup>2</sup> Arthur Alexander, et al., *The Defense Department's "Support of Industry" Independent Research and Development (IR&D)*, RAND/R-3649 ACQ, RAND Corporation, April 1989, p. 6.

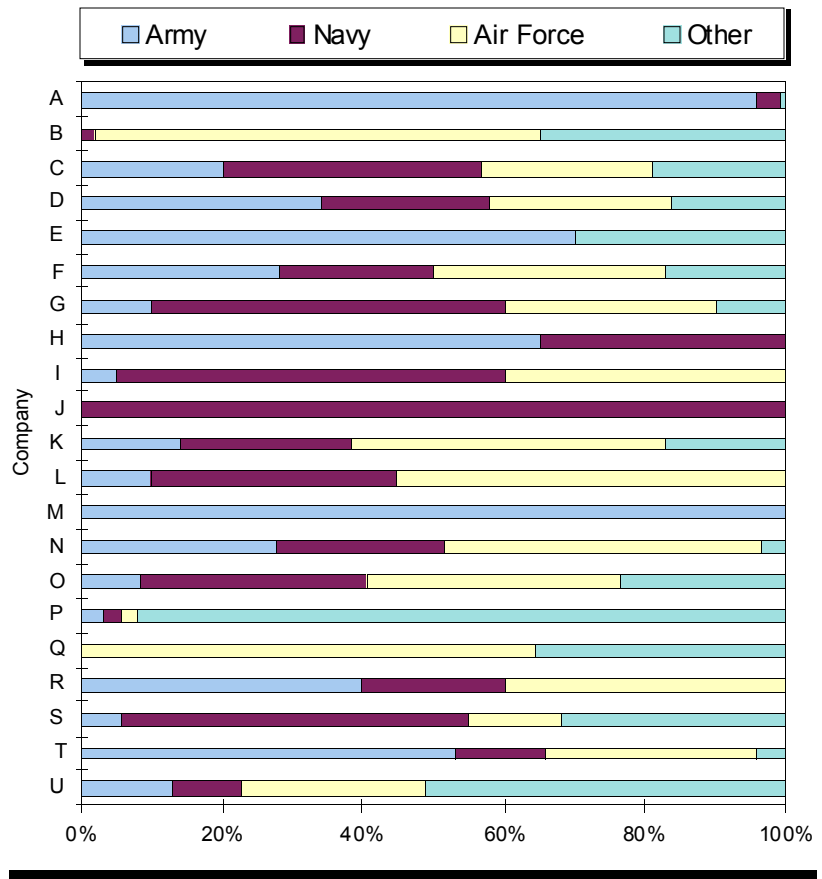


Figure 2: Major Defense Customers

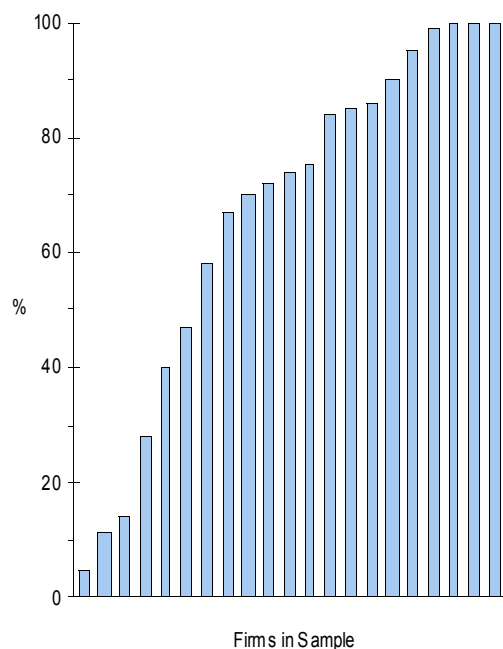
SOURCE: Survey

contract cost regulations were rewritten after World War II as a part of the new Armed Services Procurement Regulation (ASPR).

The RAND Corporation reports that in 1949, "R&D was considered an allowable cost only if specifically related to the items covered by the contract; general research expenses (roughly equivalent to IR&D) were unallowed unless specifically provided for in the contract."<sup>3</sup> Many contractors, however, reportedly insisted on the inclusion of such IR&D type costs in the contract. As a part of its decision to include such costs, the Air Force also required contractors to submit an annual IR&D plan so that the projects and costs could be reviewed and recovery amounts negotiated.<sup>4</sup>

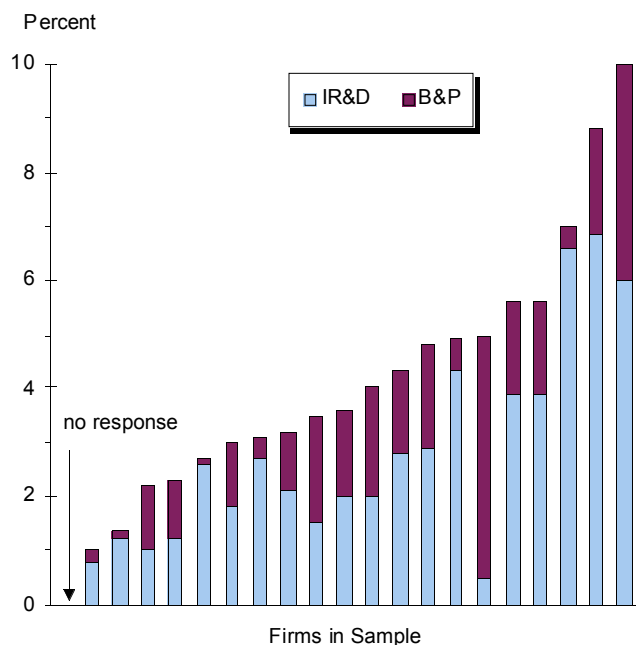
<sup>3</sup> Alexander, *ibid.*, p. 6. This was governed by ASPR, sec 15--204(s) and 250(j), 1947.

<sup>4</sup> *Ibid.*, p. 7.



**Figure 3: Percent of Total Sales that are Defense Related**  
SOURCE: Survey

This cost-based approach to contract pricing, and the oversight and negotiations of allowable IR&D, dominated defense procurement up to the changes that occurred in Fiscal Years 1991 and

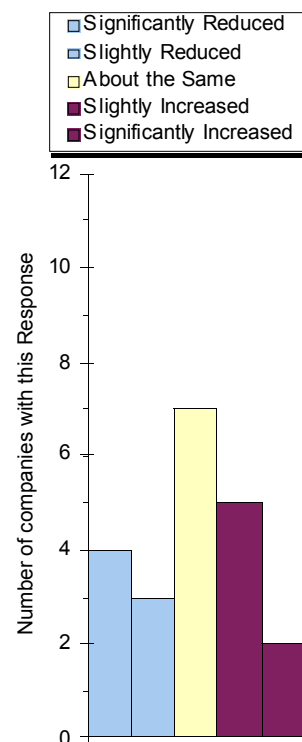


**Figure 4: IR&D and B&P as Percent of Total Sales**  
SOURCE: Survey

1992.<sup>5</sup>

The oversight and reimbursement process associated with the IR&D program grew more complicated over time. By the early 1980s, formal reviews and published plans were elaborate affairs. The arguments over the scope and efficiency of IR&D oversight and proposed changes took on new urgency with the end of the Cold War and the reduction in defense budgets, especially the fall in procurement spending that began in FY 1986. IR&D investments were under pressure as firms reevaluated the opportunities for new defense business in the face of falling defense budgets.

Directly funded R&D projects also fell in real terms between 1987 and 1991 (although not nearly as dramatically as did procurement), dealing defense R&D a double blow from both fewer funded R&D



**Figure 5: Change in % of Defense Related Sales since FY 1990.**

SOURCE: Survey

programs and from an unwillingness on the part of firms to undertake defense-related IR&D in a period where future new defense work was uncertain. This situation demanded changes to help facilitate the industry's transition into a viable post-Cold War configuration.

<sup>5</sup> RAND noted that the cost-based approach to pricing has been reinforced by the prevalence of new technologies and products in the military's market basket that have no civil analogues and few antecedents. Under these conditions, costs has become the principal determinant of price.



## INDUSTRY IR&D BEFORE AND AFTER CHANGES

It was apparent early in this study that focusing simply on the legislative and regulatory changes that occurred in FY91 and FY92 was inadequate for understanding what has been occurring in the DoD IR&D program, why these changes have occurred, and what problems might be associated with the changes. Indeed, as noted in earlier discussion, a number of factors have had a major impact on the size and composition of industry's IR&D. Some of these environmental factors are outlined in Box A and discussed in this section.

### BOX A: The Changing Environment

- Pre Change: The period prior to the changes can be characterized as one of considerable government oversight; relative stability in IR&D spending by firms; focused military threat; many industry players; and large, but declining defense budgets.
- Post Change: The period after the changes can be characterized as one of minimal government oversight; IR&D spending within firms inherently less stable (both in size and character); no single focused military threat; consolidation within industry; decentralization of industry IR&D decision-making; smaller, and declining defense budgets.

### Pre Change

**Prior to the legislative and regulatory changes of FY91 and FY92, DoD exercised considerable control over contractor IR&D activities.** For those firms required to negotiate advance ceilings, the Department's annual negotiations on ceiling of allowable costs, and its technical reviews of contractor IR&D projects, allowed the government to examine the proposed research and development efforts and evaluate the military relevance of those efforts. IR&D projects were required to be oriented toward meeting defense needs. The technical quality of IR&D projects was scored by the government in a formal evaluation process which included an annual evaluation of contractor technical plans and bi-annual, on-site reviews. This scoring, and

feedback, was thought by many to be a help to industry in benchmarking the potential usefulness of the work to future DoD needs and determining where a firm's work stood with regard to other firms. Firms built up considerable databases of past efforts and "scores." They knew "informally," some of the industry averages. Further, the scoring process involved comments from government personnel that provided further indications of how good, or useful, the research might be perceived. Firms could use this information to make judgments about the utility of their work.

The negotiation process also provided some relative stability in R&D spending by the firms required to participate. Firms committed to the expenditure of a certain amount of over-ceiling profit for the coming period. To report less spending at the next negotiation was to invite a reduction in future reimbursement. In that regard, the negotiated number was a floor as well as a ceiling. Overall, as might be expected, IR&D/B&P tracked closely with total sales (government and commercial) and DoD sales. (See Figure 1.)

**The system also had a number of useful benefits to the government.** It provided some degree of government control over the nature of IR&D being pursued and supported with government funds. The government was also able to examine a firm's IR&D and B&P ratio to ensure a high IR&D ratio was maintained. By virtue of its review across the industry, the government had good insight into how much, and what type, reimbursable IR&D was being pursued. In summary, under the pre-change system, the government could influence the direction of the IR&D, control the level of B&P use, and place an overall limit on how much effort would be reimbursed. Further, since not all funds were reimbursed, the government saw itself as leveraging funds that industry might not otherwise spend.

**There were, however, a number of recognized problems with the system as it then operated.** Critics, both in and outside the government, noted that the system was costly and the process of oversight laborious. Some firms argued that the administrative costs

exceeded gains from the interchange and the government oversight.

Further, critics argued that there was no need to have government imposed IR&D ceilings. In their view, IR&D spending would be self-limiting. If a firm put too much money into IR&D, these critics argued, then the firm's overhead would rise and it would become non-competitive.

The Cold War planning structure provided some stability and direction to IR&D planning from the early 1950s until the late 1980s. The defense establishment principally focused on a Soviet threat. That single focus provided a common framework for much of the IR&D effort by firms. By 1992, however, the Soviet/Russian threat focus was far less firm. On the one hand it was clear that the Cold War was over, but there was sufficient uncertainty about the Russians to forestall any rapid changes in threat orientation. Moreover, the Gulf War served to stabilize both defense spending and the threat evaluation process. This was particularly true since the war was fought against a Soviet trained and equipped foe. On the other hand, however, the threat situation began to change rapidly with the emergence of possible regional threats. U.S. defense planning moved toward a two regional contingency environment. Few, were comfortable with the estimates for future military needs.

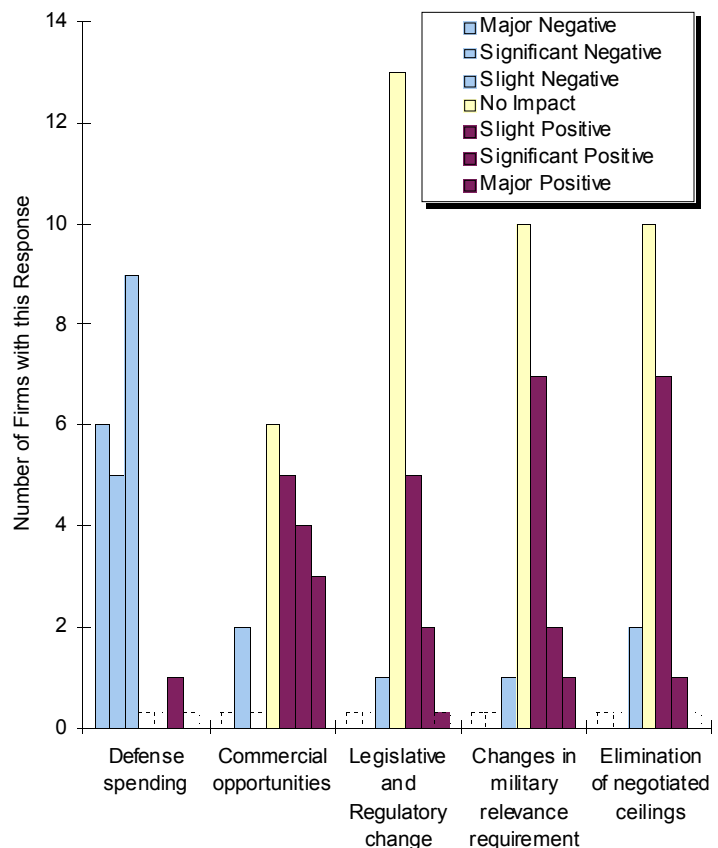
While both the defense budget and the procurement account were declining, FY92 Budget Authority was still at \$281 billion in then year dollars (\$319 billion in constant 1997 dollars). Thus, while the defense industry was aware that fundamental changes were coming, previously purchased systems were still in the pipeline, and the Gulf War spending continued to have a positive impact. Hard choices about change, and also the nature of IR&D, were not yet necessary.

Thus, discussions about future industry consolidation were still that discussions. There were still many defense players: for example, General Dynamics, Grumman, Northrop, Boeing, McDonnell Douglas, and Rockwell were all building or designing aircraft. Trends in the industrial base supported a view of a future

industrial base with fewer participants, but a continued competitive situation.

## Post Changes

The regulatory and legislative changes that occurred in FY 1991 and FY 1992 greatly reduced



**Figure 6: Factors Affecting IR&D Spending Since FY 1990.**

SOURCE: Survey

government oversight and direct influence over industry's defense IR&D program. Technical reviews are no longer required, military relevance is no longer demanded, firms are encouraged to submit information on their IR&D projects. Compliance is high and growing. While interviews indicated that there are still some direct influences on some IR&D, the legal and regulatory basis for such influence is gone.

These legislative and regulatory changes were partly in response to the end of the Cold War and were certainly influenced by that change and the falling defense budget. This post-change environment includes far fewer and much larger defense firms, e.g., two to three major firms—Lockheed-Martin, Boeing-McDonnell Douglas, and possibly Raytheon—followed by other smaller, but consolidated, and in many cases, vertically integrated firms. The initial evidence indicates that many of these firms have decentralized their IR&D decision-making.

**Industry likes the changes.** Firms reported that the legislative and regulatory changes have had generally positive effects. While several of the firms gave the legislative and regulatory changes numerical scores that indicated they had had no impact, the participants were more positive about the positive effects of eliminating the military relevance requirement and elimination of negotiated ceilings—both elements of the overall legislative and regulatory changes. (See Figure 6.) These legislative changes were seen by several of those who viewed them positively, as providing needed flexibility in IR&D expenditures.

#### Industry Says

- The single largest impact on the level of IR&D and B&P is the reduced level of defense and space related acquisition spending.
- Profitability has been under attack and has resulted in less profit to invest as IR&D.
- The actual decline in defense spending since FY 1990, and the projected continued decline in our defense market segment has been by far the most significant influence on reduced IR&D spending. Elimination of negotiated ceilings would have had a major positive impact if defense spending/sales had remained stable.

Some respondents also reported that commercial opportunities had a positive effect on their IR&D spending. An examination of these answers indicated a correlation between many of the firms who reported they benefited from improved commercial opportunities and those firms reporting a positive impact from the elimination of the requirement for military relevance. It appears that firms who had

technology that allowed them to move toward the commercial work benefited.

**The falling defense budget was viewed as having the greatest single negative impact on firms' IR&D spending.** This, of course, appears obvious—fewer procurement dollars mean less IR&D. There are, however, more subtle, and we believe more profound, effects in the changes that are occurring as a result of the reduced defense budget than simply the reduction in IR&D; these are: how, and where, the money is being spent.

**Spending is more focused and more near-term.** Several firms noted that the greatest change has been in “how IR&D is spent” rather than how much is being spent. Further, many of the firms report that the criteria for selecting projects has changed—much more on affordability. This is discussed in more detail below.

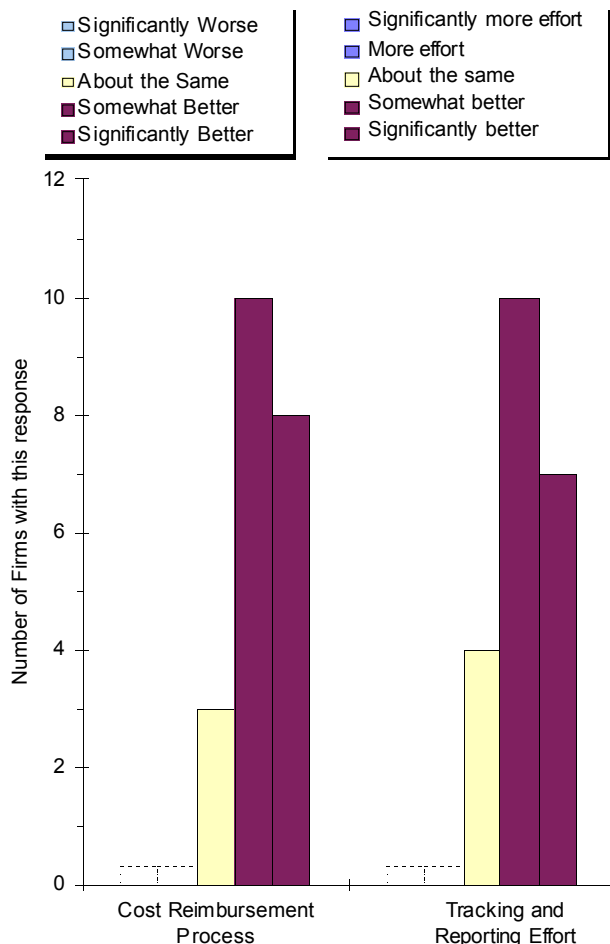
#### Industry Says

- Market opportunity and affordability drive IR&D spending.
- The major shift has been how IR&D is spent, rather than overall spending.
- The amount we spend is a balance between competitive rates and desired technical competitive position.

**One important effect of the falling budget is the consolidation among the defense contractors.** These consolidations have resulted in firms with scores of operating divisions (in one case, 82). We know from discussions with industry that many of these firms have consolidated or closed central corporate R&D activities and are decentralizing their IR&D management decisions.

**Respondents generally reported that IR&D decisions were made at the Division level, although some are consolidated at Group or Corporate level.** One major concern is that the pressures of meeting profit objectives at the Division level will further increase the near-term focus of IR&D. This near-term focus appears to be happening, and is discussed in more detail in the section on **Character of the Research Before and After Change**. The degree to which the IR&D focus is being driven by new organizational structure is unclear. It is also unclear what the government might do about





**Figure 7: IR&D Administration After Change**

SOURCE: Survey

this situation. However, it is an important factor to consider.

A second concern arising from the changing corporate structure is that firms will have difficulty investing in new product areas since Divisions, forced to meet near-term profit objectives, may concentrate spending on current products. Firms commented on the difficulty in moving investment funds across divisions. Initiating new products not aligned to existing divisions might be more difficult in a decentralized environment. It is again difficult to know at this point, the extent to which this is occurring, but answers to questions about R&D focus indicate that a trend toward iterative product improvement is evident.

**The perceived administrative burdens associated with DoD IR&D has been**

**significantly reduced by the regulatory and legislative changes.** Firms generally reported that the cost reimbursement process is somewhat, to significantly, better. (See Figure 7.) And, they reported that the tracking and reporting efforts were also much easier. No respondent thought the processes were worse. Among those reporting the burdens were about the same, one firm reported that “local Defense Contract Management Command (DCMC) technical and financial staff retained the old cost reimbursement process.”

#### Industry Says

- Less administrative oversight and interference encourages more investment. Costs for administration are significantly reduced.
- Documentation for proof on rights is still costly.
- Issues with regard to categorization of costs, selling cost v. B&P or IR&D v. demonstration costs have been eliminated.
- Elimination of ceilings and on-site IR&D review for negotiation purposes have been helpful.
- Process was cumbersome, expensive and not effective. The only remaining issue is how to communicate effectively the directions and results of the IR&D program to the government.
- To negotiate advance agreements...we do not have to use the formulas and thus are somewhat better off.

Project tracking still goes on. For example, firms still track and internally report on projects for their own purposes. There are still accounting issues and several firms commented that the documentation for proof on rights remains too burdensome. Firms also use the project reports in marketing. What they report they do not have to do, however, is to develop a detailed report for the government. They universally like the changes.

#### *Character of Research Before and After Change*

**Firms report a decided move away from basic and applied research and much more concentration on near-term product development.** (See Figure 8.) Firms almost universally reported this near-term focus. (See Figure 9.) Several respondents reported that the IR&D work in their organization has moved away from innovation and is now concentrated on

iterative improvements of current products and

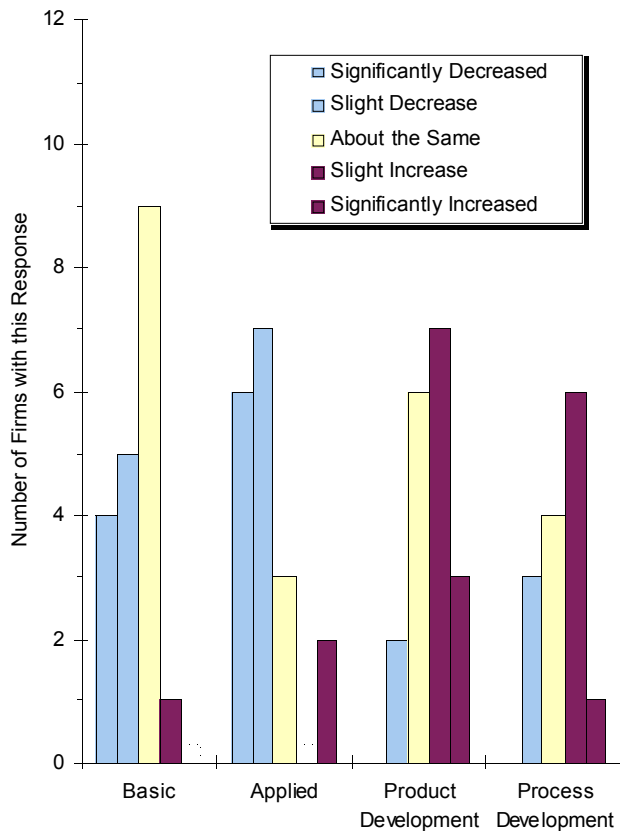


Figure 8: Change in Composition of IR&D Since FY 1990

SOURCE: Survey

affordability enhancements.

Firms gave a number of reasons for this near-term shift. One noted that the investment community's concentration on financial performance in the face of falling defense budgets helped reduce IR&D investments and increased the pressure toward short term IR&D objectives. The reimbursement structure was cited as another problem: "The current structure for recovering IR&D expenditures tends to stifle high risk/high payoff research activities that may result in significant step-wise performance or affordability improvements in the platform. Since IR&D expenditures get reflected as overhead, there is an expressed need to see immediate payoff in IR&D investments in order to justify an increase in overhead expenditures."

Again, there are indications that the practice of decentralizing IR&D decision-making to

Division level, and the pressures for profitability, have combined with the falling defense budgets to contribute to the near-term focus. While there is little that government IR&D planners can do about either the falling budgets, or the corporate structure, knowing that these pressures exist can be helpful in determining alternative ways of enticing desired investment behavior from firms. This will be discussed later in the summary and recommendations section.

Regardless of the reason for the change in the focus to the near-term, it is real and should be addressed by the DoD.

**Respondents expressed concern over the shift to near-term research.** The firms reported the move to a more short-term focus is essential given the uncertainty of the business situation and the lack of available funds, but they worried that the over concentration on the near-term could have important long-term consequences. As one participant noted: "Our focus on near-term research and development could potentially undermine our competitiveness on long-term opportunities." On a broader sense, it can potentially undermine the overall technological superiority of future U.S. forces.

#### Industry Says

- FY 1990-1994 saw significant diversion of IR&D to commercial or dual-use initiative, which has subsequently been redirected back to DoD.
- Closer linkage to business opportunities, and shorter time lines to product implementation.
- Reduced defense budgets prompts us to see opportunities ...outside of the defense market.
- Lack of continued emphasis on "dual-use technologies is a problem. The TRP program "came" and "went" quickly.

**Firms report they are generally working in the same technical areas as before the changes, but that much of their IR&D is concentrated on projects aimed at reducing costs.** This differs from previous focus that stressed increased performance. DoD's desire for cost reduction is cited as the driver. While cost reduction is certainly an important factor in a period of diminished budgets, the observations reinforce the concerns over the potential

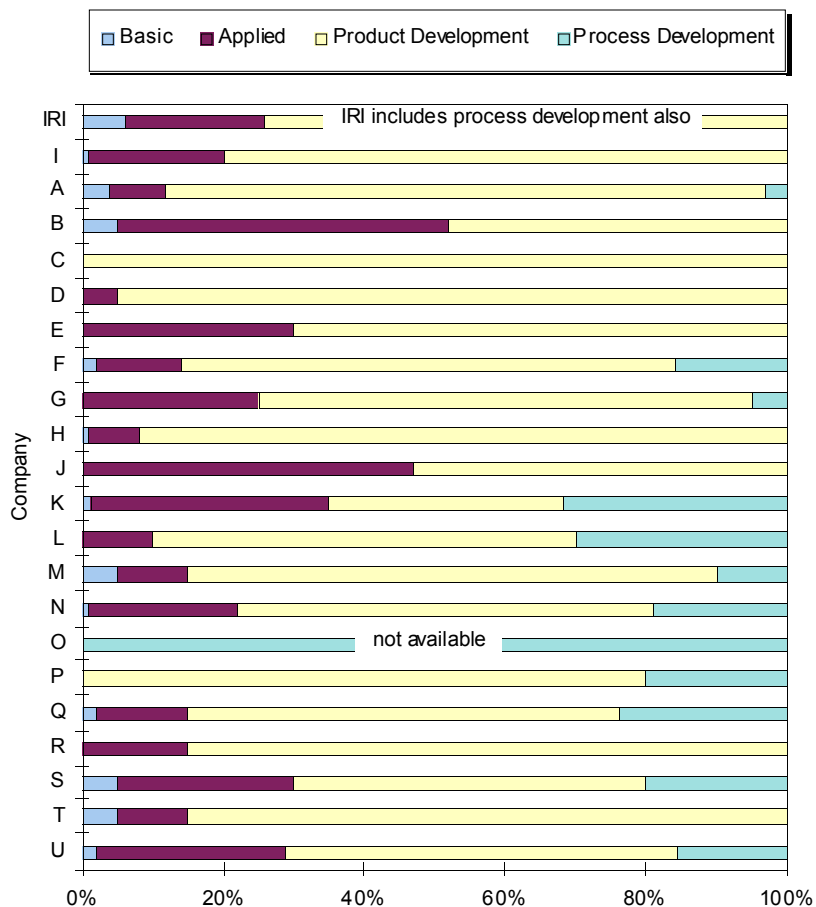


Figure 9: Current Composition of IR&D.

SOURCE: Survey

negative implications for future battlefield technological dominance of the current IR&D research focus. (See Box B.)

Several firms reported that dual-use was an increasingly important consideration in IR&D decisions. Another respondent, however, reported that his firm had moved away from a dual-use focus. The problem here, as in many areas, is a lack of clear understanding of what is really a priority for the DoD. Dual-use to date, has received more lip-service than financial support.

The heavy concentration on defense exhibited by the study group, raises questions about the ability of these firms to adequately support the current stated DoD objective of placing greater reliance on

commercial technology. This was not a question that was asked, but the defense concentration shown in figure 3, raises concerns over the ability of the defense contractor community to adequately access commercially developed technologies for use in defense systems. The mixed responses on this subject received from the companies indicates a skepticism about the activity.

Firms report they are attempting to maintain research and development in the face of budget cuts. Several respondents noted that their firms were taking a reduction in profits in order to maintain their current level of IR&D spending. In general, the relative percentage of IR&D/B&P has been maintained, but spending has fallen in absolute terms.

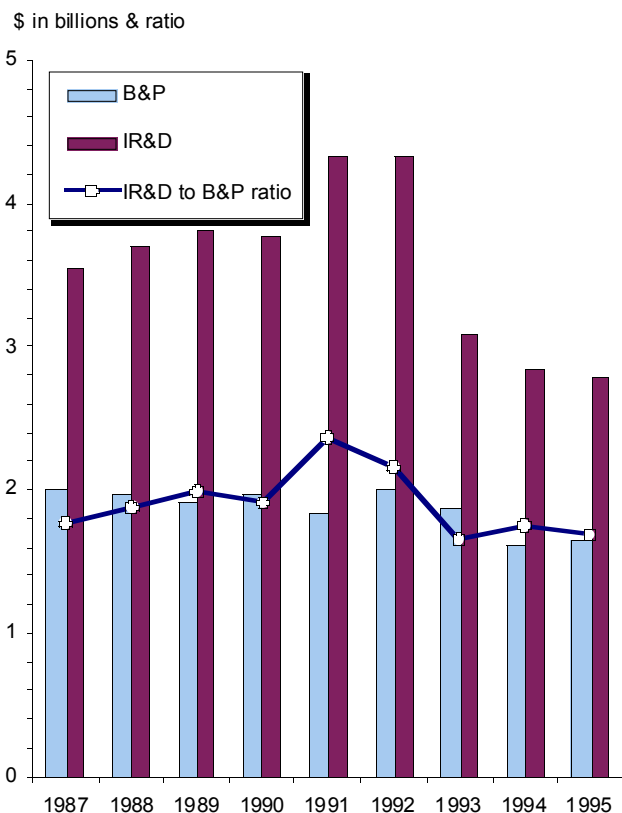
There is currently a great deal of misunderstanding of what process research can, and should, be undertaken as IR&D. Some respondents reported that they were conducting process R&D. Others, however, reported that there have been legal problems in this area because of the classification of process development activities. Current FAR guidelines (31.205-18) dictate that process development activities should

not be undertaken using IR&D funds. Improving process is very important for long-term savings. Some companies appear to be inhibited in the use of IR&D funds for this effort. This appears to be a topic that the DoD needs to study and to ensure a common definition and understanding.

Small firms expressed concern over the IR&D clout increasingly held by a few large firms. These small firms noted that a few large firms are now able to leverage their available reimbursable IR&D funds so that they can preempt DoD direct funded R&D efforts in critical areas. They can (and it is argued do), thus drive out competition in those areas.

## Box B: Areas Currently Being Studied

<p><b><i>Systems</i></b></p> <p>Forward Looking Radar GPS Integration and Inertial Navigation Packaging Navigation GPS Guidance System Avionics Systems IFF System High Speed Vehicle Systems Systems and Software Gas Turbine Engines Liquid Propellant Rocket Engines Flight Simulation Vehicle/Weapon System Concepts Engine/Suspension Systems Dual Mode Rocket Engine Radar Systems Communication Systems SIGINT/ELINT Systems Guidance Systems Naval Propulsion Systems</p>	<p><b><i>Subcomponents</i></b></p> <p>Vehicle Electronics Silicon Sensors/and Silicon Sensor Packaging MEMs for Instruments Fiber Optics ASN Electronics/Vetronics Missile Components Advanced MIMIC Devices Microwave and Millimeter wave Components for Space Communications</p>
<p><b><i>Components</i></b></p> <p>Motion control components Mission components Silicon Sensor Based Displays Displays Smart Cockpit Display and Processing Controls and Navigation Displays Advanced Avionics/components Sensors Avionics IR Sensors Fiber Optic Sensors EW Receiver Antenna Active Aircraft Controls Warheads Improved Sensors and Motion Control Components</p>	<p><b><i>Materials, Technologies and Other Activities</i></b></p> <p>Acoustics and Hydroacoustics Structures and Shock Fluids and Hydodynamics Advanced Materials and Structures Advanced Aerodynamics and Propulsion Survivability and Signature Management Modeling and Simulation Reduced Costs of Manufactured Parts Massively Parallel Processing Image /Battle Processing Surveillance Management Precision Strike Information Warfare Propellant Formulation Propellant Processing Mobility Low Observables Aeromechanics Methodologies Structure and Damage Tolerance High Speed Machinery Technology Chemical Agent Detection and Qualification Ring Laser Gyro Technology Directed Energy</p>



**Figure 10: Total Reported IR&D and B&P**

SOURCE: DCAA

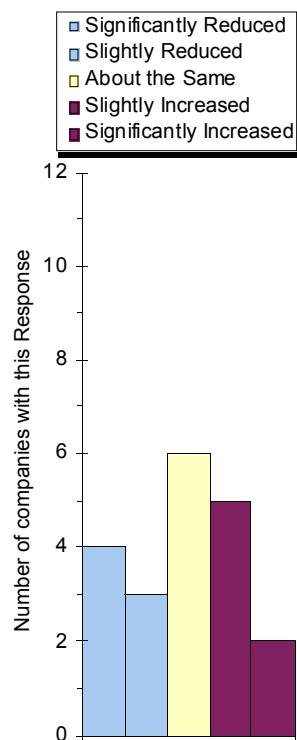
The concern over the growing concentration of IR&D dollars in an increasingly small number of major contractors is difficult to evaluate. Whether firms are using available IR&D to preempt funded research should be studied. There is no evidence, however, that the technology coming from small contractors is inherently better than that coming from a large contractor (although the small contractors point to areas of success). Further, with the consolidation in the industry, and increased vertical integration, more of the previously independent technical capabilities are currently present within the large prime contractor structure. Whether that current vertical structure will preclude defense firms from going to small firms, or to subtler divisions of rivals for the best available technology is unknown. This is a problem that DoD should consider.

**Environmental concerns have affected IR&D.** Firms reported that the elimination of

sources of supply for certain propellants and explosives caused them to direct most of their available IR&D toward qualifying new ingredients for old systems rather than exploring new technology.

### ***Amount and Ratio of IR&D to B&P***

**In absolute terms IR&D is falling, corresponding to the falling procurement budget.** (See Figure 10.) The firms all note the negative trends in R&D activity. Figure 10 probably does not show the full extent of the change that is occurring. The data end at FY95, and they cover the transition period for the policy changes to take effect. It is unlikely that these data provide sufficient insight into longer term trends. As noted about, several of the firms reported they are using more of their profits for IR&D. But firms noted the fact that few new major systems are expected soon. Based on the responses to the survey, it is probable that without increased procurement, IR&D spending



**Figure 11: IR&D/B&P Ratio Change Since FY 1990**

SOURCE: DCAA

on defense items will show an even steeper decline in the next few years.

Among those firms who supplied such information, data on the individual firm's IR&D/B&P spending for FY95 generally showed a further trailing off (electronics is a exception). (See Appendix B.)

**The IR&D/B&P ratio has fallen slightly since FY 1992.** The individual numerical

responses to our survey question provided no clear trend on this ratio (see Figure 11). However, the verbal and written responses indicated that short term focus and an increase in B&P (should any new programs occur) is likely. Among firms who supplied such individual data, the IR&D/B&P ratio fell for the aerospace and combat systems groups, but rose for the electronics group. (See Appendix B.) The next few years will be important to understanding what might occur.



## INDUSTRY/DoD COMMUNICATIONS BEFORE AND AFTER CHANGES

### General Environment

Prior to the 1991/1992 regulatory and legislative changes, there was a long standing formal process of communication on IR&D between government and industry. Defense companies which were above a specified ceiling threshold, had to negotiate IR&D agreements, were required to submit annual IR&D project write-ups and hold bi-annual, on-site reviews. Companies received written comments and scores from the government which were considered in the negotiation process. Similarly, the bi-annual on-site reviews were required to cover at least 35% of contractor's project value and were reviewed and scored by government evaluators.

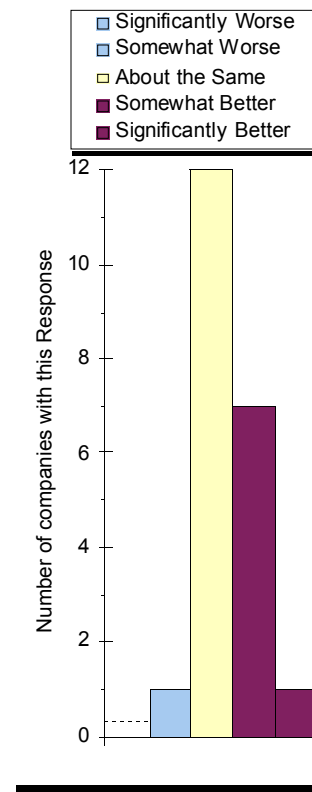
Both industry and government had extensive databases on these comments and scores and, because these databases were so large and long standing, they could provide valuable information on trends. With the new legislation, companies no longer had to negotiate ceiling agreements, did not have to submit technical plans or hold on-site reviews, and the formal scoring process was eliminated.

When asked to provide a quantitative assessment of how current communications between DoD and industry compared with those before the regulatory and legislative changes, **companies surprisingly reported communication to be about the same or somewhat better.** (See Figure 12.) This answer contrasts with other informal comments from industry which expressed concerns that communication has been significantly reduced; that industry is not getting valuable feedback on technical plans; and that technical reviews are not well attended by the right government personnel. Perhaps the earlier on-site reviews, with their extended interaction, established a basis for future communication.

In written and verbal responses, companies expressed some concerns about the nature of the post-change communications and several expressed the opinion that new ways of communicating needed to be identified. The major concern was over the need to get

information to the "right" government people and gain insight into real government needs.

Some of the concern about getting information to the right people may be met by the proliferation of organizations such as the DoD Integrated High Performance Turbine Engine Technology (IHPTET) Steering Committee and others (e.g., the National Rotocraft Technology Center, and Steering Committees on Airframes and Rockets) which



**Figure 12: Communication between DoD and Industry**

SOURCE: Survey

involve both government and industry personnel in defining technology needs and opportunities in specific areas and provide an opportunity for participating firms to discuss their IR&D efforts, as well as funded R&D opportunities with the government participants.



#### Industry Says

- With formal reporting no longer a requirement, we had to informally retrain our IR&D principle investigators to know their customers. This involved increased communication through visits, project briefings, etc.
- Industry DoD communication has increased, but very few DoD initiated reviews have come along to replace on-site reviews.
- Slight reduction in communication with the elimination of on-site reviews\_ this is offset by better communication via the WWW.
- Interchanges are more focused now.
- The best communication occurs in smaller more focused meetings.
- The IR&D On-Site reviews provided a formal, structured opportunity for data exchange at top management levels. Effective communications currently occur at all levels probably more the result of the current defense funding climate rather than any legislative changes.
- Formal “graded” reviews often created a tense atmosphere. Now communication seems more open. More sharing of information.
- Requirements changes made identification of customer needs more difficult.
- Company makes special effort to discuss IR&D progress during reviews with customer on contract R&D.

#### Government Documents

Most companies reported that government documents were useful in planning IR&D, but some commented that government documents can be contradictory and that personal contacts with the R&D decision makers are essential to understand DoD needs. During informal meetings, a major issue expressed by industry was the lack of insight into long-term defense needs and real program requirements. These concerns appeared in some of the responses on the questionnaire too. Confusion resulting from the end of the Cold War and the downturn in procurement was also noted.

The plans are reportedly used by the larger firms to help determine the critical needs of their customers. These documents provide an assessment from the user community of their perspectives on technology needs. The plans generally are considered to be written at too high

of level of be useful to smaller firms with smaller product markets. Moreover, respondents noted that there is really an overwhelming amount of data and companies are often confused about the real defense needs.

#### Box C: Government Documents

A number of documents were cited as useful, although often contradictory.

Useful documents cited include:

- MAPs, TAPs, PEDs, New World Vistas, Space 2020
- DoD Strategic Plans and Technology Roadmaps
- Government Laboratory Planning Documents
- Army Science and Technology Master Plan
- Army/Service Modernization Plans
- Advanced Planning Briefings to Industry
- Requirements Documents
- DoD Rotary Wing TDA Objectives
- Naval Aviation Plan
- DARPA and DoD Science Technology Plans
- Briefings to industry by government laboratories were also cited.

There were a number of suggestions for improving the documents. Firms liked the increasing availability of the documents electronically and thought that this mode of distribution should expand. Not surprisingly, they wanted to see more detail on priorities and funding. In general, however, the current documents got passing marks and were considered useful\_ if combined with close interaction with the customer.

#### Industry Says

Several firms argued for an earlier release of the documents to industry. A few suggested that having all the documents available at the same time would result in a closer relationship to meet investments. One firm suggested that all documents should be published no later than 30 June so they could be used to establish investment plans for the following year.

Other suggestions included:

Better insight of project priority and funding availability.

A common process across all DoD agencies, and hot links to S&T Plans from internal corporate home page.

Smaller companies reported that there was need for a finer level of detail (e.g., “good reading but at too high level”) and that many were not relevant.

### **Feedback on Reports Submitted to DTIC**

**Almost all companies in the study submit Technical Project Reports to DTIC, however, they report getting very little to no feedback from these reports.** This lack of feedback is in sharp contrast to the feedback companies reportedly got prior to the legislative change.

#### **Industry Says**

- Get many calls regarding AF Technology need hits. Process needs/requires automation.
- No feedback, other than receipt acknowledgment.
- Only a couple of calls/year directly cite the documents.
- Feedback related to IR&D with CRADA very useful.
- More interaction/comments on the reports would improve communications between customers and suppliers.
- Exchange of reports typically facilitate communications in that they provide a common point of departure for follow-on technical discussions.

**Despite the limited amount of feedback, respondents said that the feedback they did get on reports was somewhat useful.** (See Figure 13.) Industry's assessment of the value of responses, however, varied from *no use* to *extremely useful*. Given the limited amount of feedback to industry this is an area that might be improved.

#### **Industry Says**

- Responses generally identify areas of mutual research interest and provide the catalyst for further data exchange. The back and forth sharing ultimately results in a complementary vice competitive relationship.
- Basic, applied or product development government personnel control flow of program dollars; therefore, feedback has tended to feather their nest, not help industry.
- Provide valuable insight into technology needs as well as alerting us to potential future CRADA opportunities.
- User interfaces and comments are helpful in planning our investment strategy.

**Most companies reported that regulatory and legislative changes significantly reduce administrative costs of reporting.** This appears to have been a major area of savings, but

the changes may also have incurred costs that have not been quantified since firms may now have to make more trips to government locations to present their work. The development of electronic links should greatly facilitate some of this interchange. Most studies of technology transfer, however, indicate that the transfer is best done face-to-face.

#### **Industry Says**

- We streamlined our IR&D support staff and took measures to improve electronic publishing of annual reports. Also, we intensified customer coordination to remain focused on technology challenges.
- Electronic prep and distribution of plans reduced documentation costs.

Suggestions to improve the current reporting mechanism included the elimination of annual format changes, making the reports on-line via the Internet with company access control, and making more use of secure electronic media. Respondents also recommended the creation of Navy and Army IR&D homepages resembling the current Air Force site.

## Review of Contractor Plans and Projects

**Companies report having technical reviews with customers.** These include a range of formal and informal meetings.

Prior to the change, reviews as noted earlier were formal and provided feedback from designated government reviewers. The reviews are now voluntary and there is no grading. Firms report it is often difficult to get proper government attendance. The format and procedures are evolving.

There are also a number of other mechanisms that are evolving that appear to present ways to provide excellent communications between the relevant government personnel and industry. The IHPTET Steering Committee has been mentioned earlier. The Steering Committee is composed of government and industry representatives and sets goals. The industry participants use the IHPTET Plan to develop their own technical plans and then review these plans with the government. This provides for an exchange of information.

### Industry Says

- Technical reviews are scheduled with various government services, laboratories and end users.
- Informal technology forums and expositions are held on an annual basis.
- Over the last three years we have had only one formal review.

**Most firms stated that the feedback from technical reviews is also useful.** (See Figure 14.) The feedback is seen as useful in directing investments and developing new work. Firms reported that they got some general indication of how well they were doing relative to others.

It is difficult to quantify the value of regular face to face meetings in the process of technology exchange. It is clear, however, that these face to face meetings have a positive impact. On-site reviews provided a forum for technologists to meet, exchange ideas and maintain lines of communication on a regular basis. Industry has commented that these reviews provide valuable feedback. During these times of increasing uncertainty about future defense needs it is more important than ever to maintain good lines of communication between government and

industry. Ways of maintaining and improving

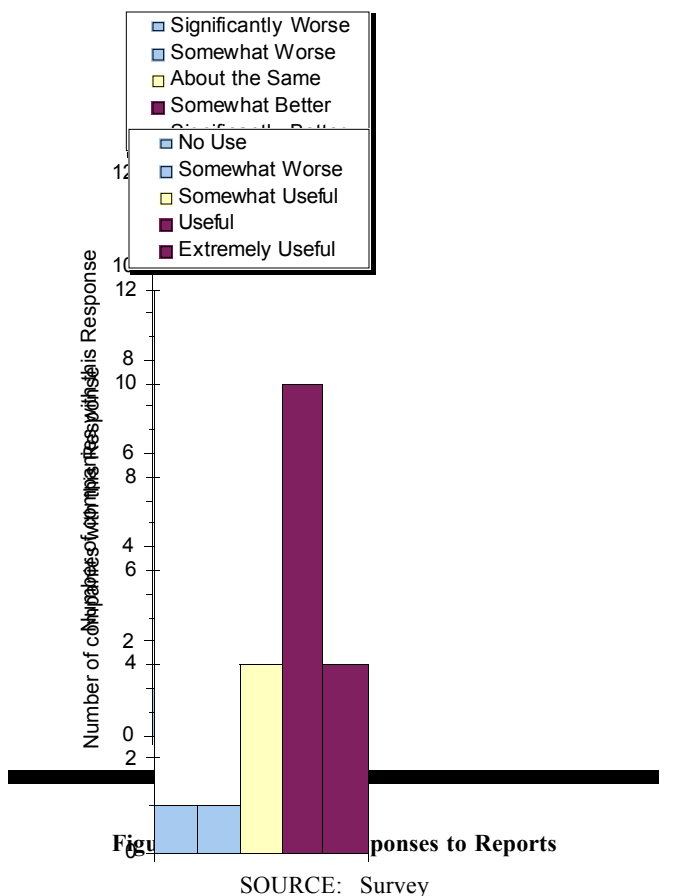


Figure 14: Value of Technical View Feedback

SOURCE: Survey

communications should be explored.

### Industry Says

- More top level, key or influential customer involvement in the technology exchange process.
- More proactive DoD support of reviews is needed. Identification of DoD technology focal points to larger industry community required.
- More government reviews at our site in specific technical areas.
- More involvement by the procuring agencies.
- With the consolidation of the industry, holding reviews at contractor facilities is probably more affordable. Could hold alternate reviews off-site convenient to government reviewers.

Industry suggested a number of improvements to the reviews. They revolve around the need for

greater participation of relevant government personnel.

In general the technical reviews are seen as having led directly to sales or being an important part of the process to get sales. Firms reported that although new ways of communicating are being used, the primary mechanisms are still face to face meetings.



## EVALUATE THE ADEQUACY OF SELECTED DoD ACTIVITIES

### **Technical Interchange Meetings**

**The technical interchange meetings appear to have changed considerably since the FY 1992 changes.** The technical interchange meetings described by the firms include all meetings in which technical data are exchanged, not just the more formal meetings falling within the previous definition. (See Box D.) Firms generally report that they have many opportunities to meet with customers and present findings from their IR&D projects. However these interchange meetings are much less formal than in the past, and as noted in the communications section, firms complain that it is often difficult to involve the “right government personnel” in these meetings. Further, given the limited government travel funds, firms report that it is difficult to get government personnel to on-site visits. On-site visits are seen as particularly useful in getting the DoD personnel to really understand projects.

#### **Box D: IR&D Technical Interchange Meetings**

##### **BEFORE LEGISLATIVE CHANGES**

- A formal process
- Required on-site reviews bi-annually
- Meetings covered at least 35% of company IR&D project value
- Briefings followed a set format and were scored
- Companies got feedback of scores and comments

##### **AFTER LEGISLATIVE CHANGES**

- Informal process
- Interchange meetings no longer required
- Reviews more focused
- Government attendance not required\_ difficult to get attendees
- Briefings not scored

Study participants noted that they are making greater efforts to get out and meet with customers and that they use the IR&D work as a marketing tool. It appears that firms that are aggressively attempting to meet and market their customers do not have a real problem with the current evolving nature of technical interchange meetings. Some report that they have had to retrain many of their personnel to make a greater

effort at customer interface, but that is an accepted part of the new business environment.

Technical interchange meetings can be effectively carried out in the current environment, but it would be helpful if DoD personnel had more travel funds.

### **Technical Reports**

As previously stated, industry submits technical write-ups on IR&D projects but receives virtually no feedback on these reports. Prior to the legislative changes, government evaluators were required to review these reports, score them, and this feedback was provided to industry. (See Box E.) The extensive database for this information provided useful market insight to industry on the relative standing of their research activities with the rest of the industry on the relative standing of their research activities with the rest of the industry and what was going on in government laboratories. Government researchers were reviewing more than one company's reports and had a good idea of what was happening in the industry. The system was forcing both government and industry to communicate.

#### **Box E: IR&D Technical Report Process**

##### **BEFORE LEGISLATIVE CHANGES**

- A formal process
- Contractors who negotiated advance agreements required to submit project reports annually
- Government evaluators required to review and score reports
- Contractors received scores and comments
- Scores were used in negotiation process

##### **AFTER LEGISLATIVE CHANGES**

- Informal process
- Contractors encouraged to submit reports to DTIC
- Government reviews and scores no longer required
- Contractors get virtually no feedback on reports
- No advance agreement negotiations

With the new legislation, the long standing system abruptly stopped. It is hard to quantify the impact of this change after only a few years,

but from industry comments it appears that the government feedback to industry is inadequate and the feedback mechanism should be reviewed. Significant effort in generating these reports is still being expended with apparently little utility to either government or industry. Organizations such as the Integrated High Performance Turbine Engine Technology (IHPTET) Steering Committee, or current service Centers of Excellence, should be evaluated to see whether a pilot program of “Centers of Excellence” could provide better feedback to industry. (See Box F.)

**Box F: Proposed Center of Excellence Pilot Program**

- Establish a Center of Excellence for a specific technical area/system (radar, acoustics, navigation and guidance, etc.) staffed by experts who are players in future service procurement.
- Establish requirement that Center review IR&D reports
- IR&D reports applicable to this Center coded and sent electronically or sorted and distributed by CD.
- Center experts review write-ups and provide qualitative assessment and comments to industry
- DoD has team of experts across Services knowledgeable about industry activities and able to provide valuable feedback to industry and guidance on procurements
- Industry has a government group they can interface with for advice. Approach could help develop longer term technological goals and increase IR&D long-term investments.

Organizations like IHPTET Steering Committee which are focused on a specific product area, can provide valuable insight on product attributes. Establishing how many organizations of this type exist, what areas of the defense industrial spectrum are covered by such organizations, and what policies would have to be implemented to encourage a greater number of defense areas being covered, should be undertaken.

However, it must be noted, that while these types of organizations might be helpful for specific product areas, a major problem remains: the prioritization of requirement/needs across product areas. Here, a higher level of government/industry interaction is required and should be considered. Roundtables at the right level might provide a needed mechanism.

## ***Matching Defense Requirements to IR&D Projects***

It is to the benefit of both the DoD and industry to improve the match between defense requirements and the IR&D Projects. As noted in earlier discussion on communications, most study respondents believe that the current process for matching defense requirements to IR&D projects could be improved.

Most of the firms reported that they believed their IR&D program provided good value in developing new weapons systems. However, this judgment has to be considered in the context of many of the firm’s reporting that they do not have a good understanding of what systems the Department of Defense might really be interested in buying.

**In light of the amount and sometimes conflicting nature of information regarding future defense needs, it is difficult for industry to prioritize R&D investments.** Program plans which present prioritized needs, and an understanding of the potential impact of technology on satisfying those needs, would help provide a frame of reference for industry to prioritize their technology investments. If these plans were linked to future procurements, the process would reinforce industry investments in the “right” technologies.

The study suggests better communications are essential. This sounds easy on the face of it, but appears difficult in practice. The current concentration appears to be on improving the flow of electronic report data and promoting its use through transmission to DoD offices who might use the information. This process has promise, but may be insufficient. Most studies indicate that technology information is best transferred through personal contact.

## ***Oversight of IR&D Program***

One of the questions often asked is how effective is the IR&D program\_ or put another way, what is the return on the investment made in the program.

Defense industry has some of its most creative people working in its IR&D, developing new technologies and products. Improving the efficiency of these investments has a multiplier

effect on improving the effectiveness of the industry.

Several times in this report we have noted the difficulty of making a definitive statement about

the returns on investments. One way to judge the returns is to examine products. Firms, asked to report their results, listed the items in Box G.

#### **Box G: New Products Developed from IR&D Programs**

<b><u>Systems</u></b>	<b><u>Components</u></b>
X-36	Integrated guidance set
B-2 Bomber	C-17 vertical tail
F-18 E/F	Advanced spacecraft buses
JSTARS	Electronically scanned active arrays
GATS/GAM Precision Weapons	Digital RLG
Solid-State Radar	Fiber-optic gyro
Dual mode rocket engine	Low-cost rugged HMD
JT8D	High performance chemical - oxygen - iodine laser
PW2000	Solid state lasers Lightweight solar arrays
F117	Control design tools for low-cost controls
V2500	World's first production fiber optic gyro for commercial aircraft
JT9D	Optical phased array to electronically steer a laser beam
PW4000	Ring laser gyro
S-92 (dual use) helicopter	Hemispherical resonator gyros
Cipher TM unmanned vehicle	Interrogator/transponder radar
Remote Molecular Monitor - ARPA TRP	Glass cockpit
Gamma Ray Imaging System ARPA TRP geared to nuclear power industry	Advanced digital flight control computer
ATACMS	Modular Radar for a variety of ground and airborne missions
Bunker Defeat Munitions (BDM) for U.S. Army	New transmission for the M113A3 Rise Program
Armored Gun System (NDI, developed under IRAD, 1984-92)	Converting the MBT to a diesel application
Bradley derivative vehicles (CZV, ATTV)	Sidewinder gas generators
Bradley A3 (initiated under IRAD, 1994)	Munitions dispersion system for Tomahawk
IDS-ATD program (initiated as IRAD seed money, 1994)	Base burner units for M864 155mm artillery projectile
Fiber optics acoustics ASW systems	Rocket motor for M913 105mm artillery projectile
F-22/JSTARS Radar	Rocket motor for M785 rocket assist 155mm artillery
Moving real time map display systems	Bomb racks for helicopters
NSSN two man ship control station	Auto air bag inflators (dual use technology)
The Embedded GPS Inertial (EGI) System	Permanent magnet motors for submarine auxiliary systems
The 8mm RLG System (HG1700)	Permanent magnet motors for submarine electric drive
Aided GPS Navigation systems	Helmet mounted display
<b><u>Subcomponents</u></b>	<b><u>Materials Technology and Other</u></b>
GaAs and InP low noise amplifiers	Pressure sensitive paint
AD converters	Investigation into IR windows led to the development of aluminum-Oxynitride, a high strength glass that can be used for bullet proof windows applications
Space qualified processors	PVF (Poly Vinylidene Flouride) sensor material has been applied to commercial fish finder system
Solid state recorders	All-composite material rotor blades
Superconducting AD connectors	IR&D focused on development of proprietary predictive capabilities. These include: shock, acoustic, structural and hydrodynamic modeling codes.
Miniature inertial measurement unit	
Integrated Flight Management Unit	
The Single Car Altimeter	
The Advanced Metal Tolerant Tracker	
Color Helmet Displays	
Silicon Accelerometers	



Some of these are rather grand—the B-2 bomber, but many are small, and even the large ones, on investigation reveal that only parts of the systems were developed under IR&D. All, however, indicate the search for new, useful products. Some took years to come to fruition. Certainly the B-2 did. Some may illustrate remarkable innovation—the stealthy aspects of aircraft. Others are acknowledged to be simply further development of an existing product. Regardless, the products are a very positive supporting argument for the IR&D program. And, in the absence of any change in cost based contracting, the program needs support. One company noted that: “all products introduced within the last several years have 10 years of IR&D! (hundreds of man months). These program developments cannot be afforded in the future.”

All of the DoD’s research activities are intertwined, and the Department must coordinate its oversight of IR&D with its other research oversight activities. One of the Department’s responsibilities is to protect its R&D capabilities—including IR&D. To adequately

explain the IR&D role, the DoD needs sufficient understanding of where companies are spending their IR&D funds to provide a reasonable report to the Secretary of Defense or to relevant committees of Congress.

A good deal of information on IR&D spending in critical technical areas (new materials, aircraft engines, large rockets, airframes, etc.) appears to be available from DoD sponsored technical areas oversight committees or centers. Aggregate data should be collected from these sources and used to provide information. No new reporting scheme should be instituted for gathering data for this purpose until currently available sources are fully exploited.

As noted earlier, companies expressed considerable confusion over the legality of process development investments. These types of investments offer considerable leverage to improve the cost effectiveness of products. This confusion should be cleared up and DoD should have insight into the amount being invested in process IR&D to compare progress among defense firms to other sectors of the economy.

## SUMMARY OF FINDINGS AND RECOMMENDATIONS

Findings have been grouped into four categories: General, Investment, Communications, and Environment. Some of these findings represent statements of fact that prompt no need for an action. Other findings relate to problems or concerns that were identified by industry or the study team. In those cases, the study team has included a recommendation for action.

### GENERAL

#### *Finding*

**The legislative and regulatory changes resulted in a fundamental change in the level of direct DoD control over IR&D.** Prior to these changes, DoD exercised considerable control over contractor IR&D. For those firms required to negotiate advanced ceilings, the annual negotiations and technical reviews allowed the government to examine proposed R&D activities and evaluate their military relevance. Under the pre-change system, the government could influence the direction of the IR&D, control the level of B&P use, and place an overall limit on how much effort would be reimbursed. Further, since not all funds were reimbursed, the government saw itself as leveraging funds that industry might not otherwise spend.

In the post-change environment, there are no required technical reviews, no enforced ceilings on the amount of IR&D, and no test for military relevance in the work that is done.

#### *Finding*

**The legislative and regulatory changes have reduced perceived costs and administrative burden. Industry likes the changes.** Most of this savings reportedly comes from reduced personnel involved in tracking and reporting on the projects and reduced printing costs. Industry also likes the investment flexibility associated with new system.

#### *Finding*

**There has been a fundamental change in the character of government/industry communications.** It has gone from a formal

mandated environment to an informal voluntary one.

#### *Finding*

**Companies are either increasing their involvement in defense or selling their defense interests and concentrating on commercial markets.** Accordingly the defense concentrations of the companies remaining in the defense sector is increasing. This increase could widen the gap between defense and commercial companies and could affect the transfer of commercial technology to the defense sector.

#### *Recommendation*

DoD should quantify this trend and analyze the potential impact of the trend on the ability to transfer commercial technology to defense products.

### INVESTMENT

#### *Finding*

**IR&D has fallen in absolute terms.** This is not surprising considering that it is an overhead cost and tracks procurement. Firms report that they are trying to maintain their relative level of spending, but without better information, and more certainty of return, are unlikely to spend more.

#### *Finding*

**The IR&D/B&P ratio has fallen slightly, but the trend remains unclear.** Critics had earlier argued that this would occur in the absence of DoD oversight. It is also affected by the near-term focus and decentralized IR&D decision-making. Data provided by DCAA show a light decline. The data for those firms providing this information show a mixed result with the electronics groups showing an improved ratio while aerospace and combat systems show a falling ratio. (See Appendix B.)

#### *Finding*

**There is an excessive near-term focus in IR&D projects.** This near-term focus results from several factors including: the end of the

Cold War, falling defense budgets, subsequent downturn in defense procurement, uncertainty over future defense needs, and industry consolidation and restructuring. It poses a threat to continued defense technological dominance.

### **Recommendation**

The DoD should take immediate steps to identify and promote more long-term IR&D investments. Because this trend is the result of a number of factors, there is no single activity that will by itself change the focus. There were, however, a number of ideas that came from the study. These include:

- (1) Improve the communication of future defense needs so that industry will have better insight into real program requirements and more confidence in investing in longer term projects in specific technologies.
- (2) Make greater use of mechanisms such as the Integrated High Performance Turbine Engine Technology (IHPTET) Steering Committee, and similar groupings to help guide research. There is a need to better understand how such activities currently operate and how information from them can be used to assist the DoD with its interface with industry and its overall IR&D management function.
- (3) Develop funded cooperative projects in selected technology areas of real interest to the DoD designed to draw matching industry IR&D investment. Such projects should be long-term, high-risk, potentially high-payoff projects. The projects would be funded to involve a wide range of firms in a precompetitive mode and would be designed to lead to a subsequent competitive phase. The design and objectives of these projects would be the result of cooperative decision-making between government and industry.

### **Finding**

**There is a great deal of confusion over the appropriateness of process development IR&D investments.**

### **Recommendation**

DoD should examine the current regulations dealing with process technology investments and the problems associated with such investments in the IR&D program including: (1) the confusion over the appropriateness of these investments, (2) the size and nature of current investments, (3) the use of the manufacturing programs, and (4) the impact on defense products of increased investment in process technology.

### **Finding**

**The inability to defer some of the IR&D charges to the point when sales of the future product occurs\_ if any IR&D charge is made during the period, limits corporate IR&D flexibility.** This is seen as running counter to commercial practices.

### **Recommendation**

Study the possibility of changing the rules on deferring IR&D charges.

## **COMMUNICATIONS**

### **Finding**

**The feedback and utility of interaction based on technical data submissions is very low and marginally useful.**

### **Recommendation**

The DoD is currently working to improve this situation. They are trying to identify potential government customers for submitted reports (e.g., Air Force). The DoD should look for additional ways to improve the interaction.

The DoD might, for example, examine the use of Centers for Excellence or IPTs to review technical submissions and serve as initial evaluators for the government, and sources of feedback for firms. The idea would be to ensure that every technical submission is read and evaluated and a evaluation sent to the firm and to relevant DoD offices.

### **Finding**

**Technical data interchange meetings have fundamentally changed.** The formal meetings can be helpful, but are infrequent. New mechanisms, however, may exist to facilitate the transfer of information in their place.

### **Recommendation**

In support of earlier recommendations, the DoD should study the use and effectiveness of technology steering committees, and other methods of facilitating defense needs and industry developments. It should evaluate the ability of such organizations to promote interchange, identify inadequacies, and take actions to overcome them.

Finally, the DoD might increase the level of travel funds so that relevant DoD personnel could attend on-site briefings.

### ***Finding***

**DoD planning documents and information are reportedly helpful to the large firms (less so for small firms), but confusing.** In general, firms report they get conflicting information on need.

### ***Recommendation***

In line with the previous recommendation on dealing with the near-term focus, the DoD needs to take steps to improve the level of information and credibility on future technology needs and priorities. One approach within a specific product area already mentioned above is using organizations like the IHPTET Steering Committee, the National Rotocraft Technical Center (NRTC), and others. Some companies reported that the plans developed by these organizations are the cornerstone of their own IR&D programs. The DoD needs to better understand how these organizations affect IR&D spending in their selected technical areas.

The DoD should identify all areas covered by such organizations, understand their function, charter, membership and outputs. It should evaluate the possible usefulness of these organizations in technology interchange to defense technology areas not yet covered.

The DoD should look for ways to better communicate its needs with smaller, more specialized firms; perhaps using tailored technical organizations.

### ***Finding***

**The formal technical interchange meetings are down, but the overall communication may be about the same.** Firms report they are communicating through voluntary technical interchange meetings,

informal marketing meetings, and mechanisms such as the NRTC, and others.

## **ENVIRONMENT**

### ***Finding***

**Small companies are concerned that the large, vertically integrated companies can overwhelm the business and foreclose funded R&D projects, therefore ultimately creating a monopoly situation in key areas.** These larger firms are becoming more vertically integrated and smaller companies may have trouble competing. We have not had defense companies of this size and capability before.

### ***Recommendation***

DoD should study the impact of the vertical integration going on within the industry. It should identify the amount of vertical integration within the industry and its character ( by technology and industrial area). It should evaluate the checks and balances which inhibit a large company from dominating a market.

### ***Finding***

**There is a trend toward decentralization of IR&D decision-making.** This trend may limit corporate flexibility to move IR&D money. When asked, companies stated that much of their IR&D was controlled at the division level and that it was difficult to move money from one division to another. In contrast, companies that control IR&D funds at the corporate level may have flexibility to start new innovative programs which are not part of an existing division's product line. Divisions that can be classified as cash cows may not need R&D investment, but under decentralized operations, it may be difficult to move funds to an area that has greater need.

### ***Recommendation***

DoD should evaluate the implication of corporate decentralization of IR&D decision-making and the difficulty in moving R&D funds across divisions on the ability to develop innovative defense products, and evaluate the implications of any identified trend for IR&D policy.

### ***Finding***

**Industry consolidations and the trend to decentralization has apparently reduced or eliminated many corporate research**

**organizations.** Consolidations have eliminated duplicated functions or areas of investigation. Decentralization places more power in the hands of division management whose focus is near-term profitability. Division management has argued that they do not want to give up profit dollars to corporate research organizations and loose control when they could invest those resources on efforts of potential near-term profitability.

***Recommendation***

DoD should study this trend, quantify how great it is, evaluate the trend and its potential long-term implications, and evaluate alternate approaches including stronger industry/academic relationships to offset the impact of this trend.

***Finding***

**IR&D in explosives and propellants material may be consumed by the need to respond to changes in environmental laws that drive suppliers out of business and component products off the market.** This may leave little for money for advancing the performance state-of-the-art.

***Recommendation***

DoD should evaluate the use of IR&D in areas that are especially affected by environmental laws.

## APPENDIX A INDUSTRY QUESTIONNAIRE

### IR&D Questionnaire

This questionnaire is being conducted in support of a DoD study of the effects that regulatory and legislative (P.L. 102-190) changes that occurred in the early 1990s, and changes in the defense budget, have had on DoD's IR&D program. The questionnaire is designed to gather information that can be used to assess the effects of these changes and to evaluate the current program. Some of the questions ask for both a relative numerical assessment and a subjective assessment. While the numerical assessment allows the study team to group general observations, your written comments are critical to the program evaluation. Please feel free to use additional paper if that is necessary.

We realize that some of the requested information may be regarded as proprietary. Your answers will be treated confidentially. The data will be aggregated and will not identify individual firms. We greatly appreciate your willingness to participate.

#### General Information

1(a) What percent of total sales is defense related? \_\_\_\_\_%Defense

1(b) How has the percent defense related sales changed since FY1990?

Significantly Decreased 1	Slightly Decreased 2	Stayed About the Same 3	Slightly Increased 4	Significantly Increased 5
---------------------------------	----------------------------	-------------------------------	----------------------------	---------------------------------

1(c) Within Defense, who are your major customers?

Army	_____ % sales
Navy	_____ % sales
Air Force	_____ % sales
Other (please specify)	_____ % sales

2(a) How much IR&D and B&P were performed in FY1995, as a percent of total sales?

Combined IR&D and B&P was \_\_\_\_\_ % of total sales

Of that, \_\_\_\_\_ % was B&P

2(b) How has the ratio of IR&D to B&P changed since FY1990?

Significantly Reduced 1	Slightly Reduced 2	About the Same 3	Slightly Increased 4	Significantly Increased 5
-------------------------------	-----------------------	---------------------	----------------------------	---------------------------------

2(c) What is the current composition of your IR&D?

\_\_\_\_\_ % Basic Research  
 \_\_\_\_\_ % Applied Research  
 \_\_\_\_\_ % Product Development  
 \_\_\_\_\_ % Process Development

2(d) How has the relative composition of IR&D changed since FY1990? (e.g., more or less basic, applied or development?)

	<b>Significantly Decreased</b>	<b>Slight Decrease</b>	<b>About the Same</b>	<b>Slight Increase</b>	<b>Significantly Increased</b>
<b>Basic</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<i>Applied</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
<b>Product</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
<b>Development</b>					
<i>Process</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
<i>Development</i>					

2(e) Have the criteria for funding IR&D projects changed since FY1990, and if so, how have they changed?

## Financial

3(a) At what level (corporate, group or division) are IR&D and B&P costs allocated and controlled for your firm?

3(b) How much flexibility exists in allocation of IR&D within the Corporation? For example, how great is the ability to move across divisions?

3(c) Do current government rules interfere with IR&D investment flexibility? If so, how?

4(a) What factors have had the greatest influence on your firm's IR&D spending since FY1990?

	Major Negative Impact -3	Significant Negative Impact -2	Slight Negative Impact -1	No Impact 0	Slight Positive Impact +1	Significant Positive Impact +2	Major Positive Impact +3
<b>Defense spending</b>							
<i>Commercial opportunities</i>	-3	-2	-1	0	+1	+2	+3
<b>Legislative and Regulatory changes</b>							
<i>-Changes in military relevance requirements</i>	-3	-2	-1	0	+1	+2	+3
<b>-Elimination of negotiated ceilings</b>							
<i>Other (please specify)</i>	-3	-2	-1	0	+1	+2	+3

4(b) Please explain your assessment.

### Administrative

5(a) Please compare the IR&D and B&P cost reimbursement process after the legislative changes to the process that existed before the change.

Significantly Worse 1	Somewhat Worse 2	About the Same 3	Somewhat Better 4	Significantly Better 5
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5(b) Please explain your assessment.



5(c) How much effort (people/money) does it take to track and report on projects now compared to the effort needed prior to FY1991?

<b>Significantly More Effort</b>	<b>More Effort</b>	<b>About the Same</b>	<b>Less Effort</b>	<b>Significantly Less Effort</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>

5(d) Please comment on your evaluation, providing examples of changes.

### Communications

6(a) How do current communications between DoD and industry compare with those before the regulatory and legislative changes (e.g., prior to FY1991)?

<b>Significantly Worse</b>	<b>Somewhat Worse</b>	<b>About the Same</b>	<b>Somewhat Better</b>	<b>Significantly Better</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>

6(b) Please explain your assessment.

7(a) What government documents (e.g., DoD and Service Science and Technology Plans) do you use to help plan your IR&D and how useful are these document?

7(b) How could these documents be improved? Does the fact that these documents are published at different times have any impact?

8(a) Do you currently submit IR&D reports to the government? **Yes No**

8(b) What response do you get on these reports?

8(c) How valuable are the responses?

<b>No Use</b>	<b>Little Use</b>	<b>Somewhat Useful</b>	<b>Useful</b>	<b>Extremely Useful</b>
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>

8(d) Please explain your assessment.

9(a) What were the effects on reporting of the regulatory and legislative changes in FY1991 and FY1992?

9(b) Could the reporting mechanism be improved, and if so how?

10(a) What IR&D Technical Reviews does your firm conduct with the Government and how frequent are these reviews?

10(b) What feedback do you get from these technical reviews?

10(c) How valuable is this feedback?

<b>No Use</b>	<b>Little Use</b>	<b>Somewhat Useful</b>	<b>Useful</b>	<b>Extremely Useful</b>
---------------	-------------------	------------------------	---------------	-------------------------

**1**

**2**

**3**

**4**

**5**

10(d) Please explain your assessment.

10(e) How could these Technical Reviews be improved for your firm?

11(a) Have either the IR&D reports, or the technical reviews led directly to new interest or sales?

11(b) If so, with whom (e.g., DoD laboratories or buying commands)?

12(a) What new ways of communication have developed since FY1992 (e.g., Conferences, Workshops, e-mail, Video-conferencing, Other)?

### **Technical Areas**

13(a) What are the major technical areas of your current IR&D program?



13(b) How do these areas compare with the areas being investigated in FY 90?

13 (c) To what do you attribute any changes in technical directions (end of Cold-War, legislative changes, others)?

14(a) How closely does the government participate in the technology planning and development of new IR&D projects?

14(b) Do government customers encourage specific activities or projects (e.g., either more research or increased development spending)?

### **Business Areas**

15(a) How would you assess the value of your IR&D program in developing new business (near-term, mid-term, long-term)?

15(b) Could you provide some specific examples of new products developed as a result of the IR&D program.

### **Issues**

16 (a) What are the major problems, if any, you see with the current IR&D program?

16(b) What specific problems have you experienced? How have they differed before and after the legislative change?

16(c) How have stops and starts in acquisition program funding, and the related B&P expense, affected your IR&D effort?

### **Recommendations**

17(a) What specific actions would you recommend to improve the effectiveness of the IR&D program (e.g., communications changes, legislative changes, cost reimbursement changes) ?





## Historic Data

**18(a)** We realize that consolidations, mergers and resulting changes in product orientation makes it difficult to show total sales and investment figures in a consistent manner. Nevertheless, it would be useful if you could provide your best estimates of the sales and IR&D/B&P investments for the period shown below. This data, like the rest of the data collected in this survey, will only be used in aggregate form, combined with that of the other 30 participating companies.

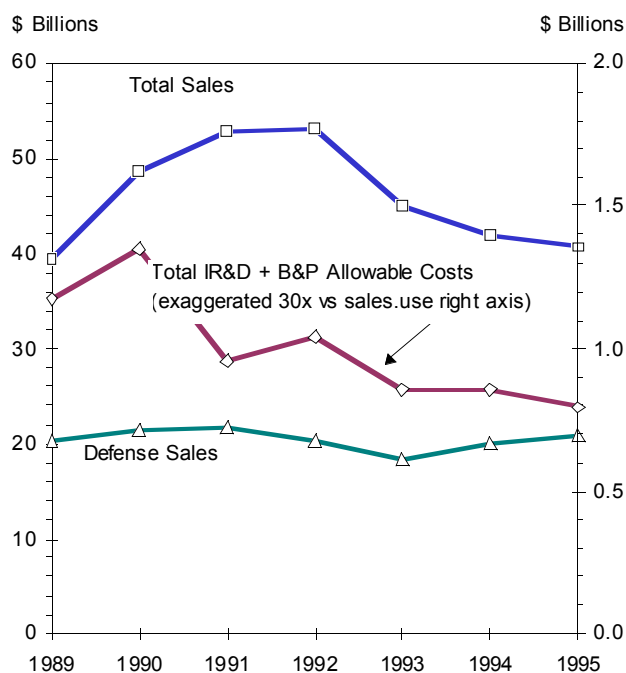
Please provide the following:

<b>Sales</b>	<b>1989</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>
<i>Defense</i>	\$	\$	\$	\$	\$	\$	\$
<b>Non-Defense</b>	\$	\$	\$	\$	\$	\$	\$

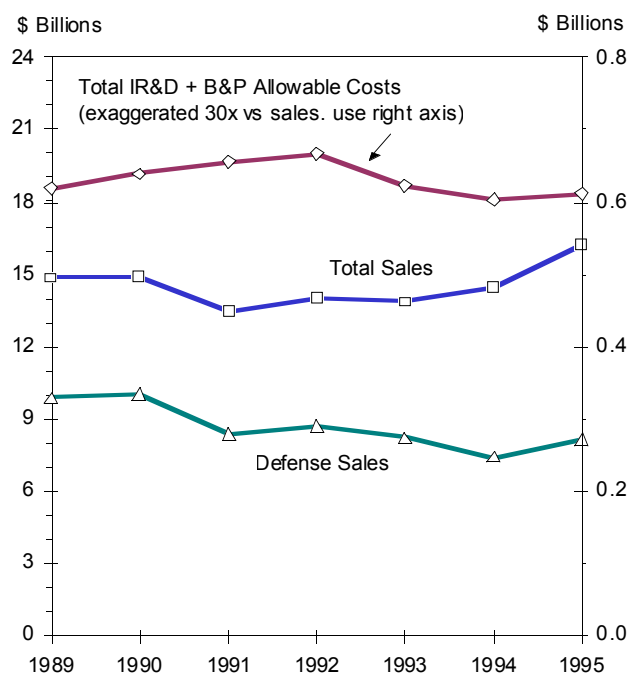
<b>IR&amp;D, B&amp;P</b>	<b>1989</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>
<i>IR&amp;D</i>	\$	\$	\$	\$	\$	\$	\$
<b>B&amp;P</b>	\$	\$	\$	\$	\$	\$	\$



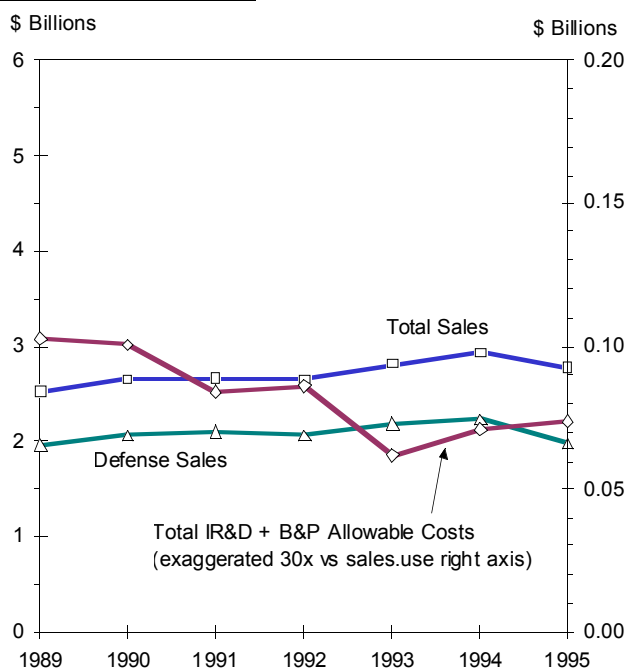
## APPENDIX B SECTOR IR&D AND B&P TRENDS



Combined IR&D and B&P vs Total and DoD Sales  
Aerospace



Combined IR&D and B&P vs Total and DoD Sales  
Electronics



Combined IR&D and B&P vs Total and DoD Sales  
Combat Systems

